

Contractor's Report to the Board

The Feasibility, Constructability, and Efficacy of Tire-Derived Aggregate as a Component in Slurry Cutoff Walls

Produced under contract by:



CALIFORNIA STATE UNIVERSITY, CHICO

CSU, Chico Research Foundation

June 2006

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Executive Summary

Overview

This project was originally developed conceptually as a potential reuse for large quantities of waste tires which may be recycled by cutting them into tire shreds. Tire shreds have unique physical properties which may be used in various civil engineering applications. In 1998, a research grant was awarded to the CSU, Chico Research Foundation to evaluate the feasibility of incorporating tires shreds into a levee slurry cutoff wall. Professor Richard G. Holman authored the study.

A slurry cutoff wall is a form of seepage barrier intended to stop the migration of water through an impervious barrier. One of the methods used to construct a slurry cutoff wall is to excavate a trench and then backfill with a mixture of soil, cement, and bentonite clay (SCB). In waterside applications, a cutoff wall is typically constructed either at the toe of the levee or along the crown (top) of the levee. The process is typically:

1. A trench is excavated.
2. The trench is filled with hydrated bentonite clay slurry to prevent the trench from caving in.
3. The soil that was excavated is mixed with bentonite and cement and placed back into the trench.
4. Samples are periodically taken to measure the permeability (ability of water to flow through the backfill material).



In the 1990's the United States Army Corps of Engineers (USACOE) constructed more than 25 river miles of slurry cutoff walls per year on various rivers in Northern California. Additionally, cutoff wall contracts were let by various government agencies including the California Department of Water Resources (DWR), and the United States Bureau of Reclamation (USBOR). The hypothesis for this project was that a large quantity of recycled tires could be incorporated into the backfill, alleviating the various piles of waste tires stockpiled in the State of California and providing an effective barrier to water migration.

The Recycled Tire Slurry Cutoff Wall Demonstration Project was funded by the California Integrated Waste Management Board as a potential source for the reuse of waste tires. The project had four distinct stages:

1. Laboratory Testing
2. Medium Scale Testing
3. Large Scale Field Testing - Implementation
4. Monitoring of Results

Laboratory Work

In 1998-1999, preliminary laboratory work was performed to determine if in fact, there was a method in which the soil, cement, bentonite, and tire shreds could be mixed resulting in a product that behaved similar to backfill materials being used in traditional SCB cutoff walls. The target used for measurement of performance was the USACOE specifications with three major criteria including:

- | | |
|-------------------------------------|-------------------------------------|
| 1. Slump – | 100–150 mm (4-6 inches) |
| 2. Permeability – | Less than 5×10^{-7} cm/sec |
| 3. Compressive strength (f_c) – | Less than 100 psi |

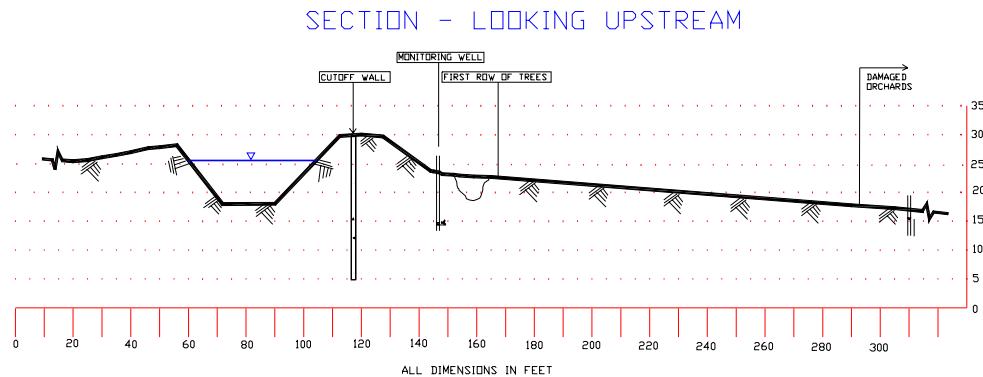
Various sizes of rubber were tested from crumb rubber to as large as 8 inch tire shreds.

After a design mix was established, a medium scale mix was constructed using a ready-mix concrete truck. From the results of this test, the mix was slightly modified and preparation for the large scale project commenced.

Large Scale Field Test

In May of 1999, a prequalification of contractors was conducted. Bid documents were prepared and bids were requested. In June of 1999, a construction contract in the amount of \$243,000 was awarded to Inquip Construction. The project consisted of construction of 1,400 lineal feet of cutoff wall on a levee in Gridley, CA. The wall was constructed 30 feet deep.

The site selected is a DWR levee between the Sutter-Colusa canal and the Feather River. This location was selected because the canal adjacent to the levee is drained and filled annually thus providing a good opportunity for monitoring.



The cutoff wall took 30 days to complete. The project was constructed using two excavators, a track loader, and an integrated tool carrier. As the excavation progressed, the soil was placed in a 15 cubic yard (CY) mixing bin similar to a large garbage dumpster. Proper amounts of soil, cement, bentonite, and tire shreds were mixed and then placed at the opposite end of the excavation. As one excavator progressed with digging, the second excavator followed with the backfill so that the trench was not open more than approximately 100 feet at any given time. At the end of each shift, fence panels were placed over the excavation as a safety precaution to prevent someone from falling into the trench.

The contractor was required to follow USACOE specifications. Slump was measured on a regular basis. Custom cylinders were manufactured to conduct permeability tests. Compressive strength tests were conducted using 6" x 12" concrete test cylinders. All tests met specification.

The Recycled Tire Slurry Cutoff Wall Demonstration Project utilized 475 tons of tires. The tires were supplied to the project by the CIWMB at no charge to the project. Most of the tires used came from a legacy site in Oroville, CA. Procedurally, the contractor indicated that there was no additional cost or productivity loss due to incorporation of the tires into the backfill.

Monitoring of Results

After the project was constructed, nine-four inch diameter monitoring wells were installed. The monitoring wells provide an opportunity to measure the depth of the ground water to determine if water was migrating from the canal, through (or around) the cutoff wall.

Weekly groundwater measurements were taken over the course of two years. Preliminary results indicated that there was water moving from the canal to the adjacent land. In other words, when the canal was filled, the groundwater level on the opposite side of the wall increased as well.

In May, 2005, the canal was filled. Prior to filling the canal, water level logging equipment was installed. The water level logging equipment was programmed to take water levels in fifteen minute intervals. After evaluation of this data, it was determined that the water appears to be migrating through the levee at both ends of the cutoff wall (not through the wall). This finding concurs with the permeability laboratory tests. From all data available, it appears that the water is making an "end around" on the cutoff wall.

Laboratory Phase

Preliminary Investigations

Prior to commencement of laboratory testing, an informal literature review was conducted. Meetings were held with the USACOE engineering staff, and site visits were made to two different slurry cutoff walls construction sites. It became apparent that a Soil-Cement-Bentonite mix design was fairly well documented however there were significant obstacles when incorporating recycled tires into the mix.

Some of these obstacles included:

- Method of mixing materials in a large scale field test
- Method of testing permeability
- Method of testing slump
- Buoyancy of the tires
- Variations of soil classification used in lab tests from those actually found at the site

The results of these preliminary investigations concluded that there are various methods used to construct a slurry cutoff wall. The first project visited mixed the soil, cement, and bentonite using a dozer adjacent to the excavation. The mixing area was referred to as a “mixing bowl”. The second project utilized a large mixing box similar to a dumpster.

Another significant issue was the desire of CIWMB to maximize the use of tires. After significant discussions with the CIWMB, it was determined that crumb rubber was not preferred due to the cost of production. This presented a challenge regarding the testing methods which could be used.

Professor Dana Humphrey from the University of Maine who is a recognized expert in recycled tire projects was contacted. Dr. Humphrey had significant concerns about the potential for buoyancy. His concern was that the tires would “float” in the bentonite slurry as the backfill material was placed.

All of these concerns were significant and could not be ignored during the mix design process.

Mix Design and Parameters

Upon review of existing data and discussions with the experts in the field of slurry cutoff walls, initial mix design testing was conducted. More than 500 pounds of shredded tires were supplied to the CSU, Chico Research Foundation. The tires supplied were in various sizes ranging from 2” x 2” up to 8” x 8”. Test mixes were prepared in small electric drum mixer.

The tire shreds were subsequently relocated to the Concrete and Soils laboratory at CSU, Chico and preliminary tests were conducted. Preliminary tests were conducted using soil from the surface of the proposed construction site. By varying quantities of water, soil, bentonite, and cement, it became apparent that the 8” tire shreds were too large. Slump became difficult to measure and the 6” x 12” compressive strength molds did not readily accept the larger tire shreds. After significant efforts, it became apparent that 2” minus tire chips would provide the best

workability and efficacy. At this time, 500 pounds of 2" minus tire shreds was delivered to CSU, Chico and an additional 500 pounds was delivered to the independent testing lab Vector Engineering.



Although the USACOE requires only eight hours for hydration of the bentonite, it was determined that twenty four hours assured full hydration and provided an effective slurry for testing. Mixes were tested using a three cubic foot electric concrete mixer. Each test mix was tested for slump and compressive strength. When a mix met both of these requirements it was sent to Vector Engineering for permeability testing. After approximately two months, a proposed mix design was achieved. Due to the viscosity of the mix, it appeared the separation of the tires from the slurry was unlikely thus alleviating most of the concern about the tires floating in the bentonite.

The final mix design proposed was:

Backfill Mix Design Provided to Contractors

Slurry Mix Item	Percent by Weight
Soil	67%
Bentonite Clay	3%
Cement	5%
Tire Chips	25%

Testing Procedures

Slump testing was conducted using the standard slump cone (ASTM C-143). The slump cone is considered accurate unless the maximum aggregate size exceeds 1.5 inches. For obvious reasons, the standard slump cone was not acceptable when using tire shreds. Even with smaller shreds, the tire chips tended to “stack” thus providing inaccurate results. To alleviate this concern, a Kelly Ball was utilized. The Kelly Ball utilizes a 6” diameter, 30 pound ball attached to a rod. A sample of slurry mix is prepared and struck off. The ball is then released and the depth of penetration is measured. The depth of measured can then be correlated to slump. The Kelley Ball test was formerly standardized in ASTM C-360-92.

Permeability Testing was conducted at Vector Engineering. Due to the size of the tire chips, special test cylinders had to be constructed. The cylinders were constructed of twelve inch diameter plastic pipe with a plywood bottom. The test procedure used was ASTM D-5084. It should be noted that the USACOE requires hydraulic conductivity not to exceed 5×10^{-7} cm/sec. This is the equivalent of 0.0000005 cm/sec. In some cases, the project achieved only 2.4×10^{-7} cm/sec. This difference is minimal and given the margin of error, it was determined to be acceptable.

Medium Scale Testing

In spring of 1999, a test was performed at Vector Engineering in Grass Valley, CA. This test involved mixing two separate batches of backfill material. With soil obtained from the site, there were two mixes prepared using a standard Cement mix transit truck.

The first mix used included the proposed mix design less the tires. The purpose of this test was to ensure that the matrix of soil-cement-bentonite would in fact meet the project objectives. The second test was the actual proposed mix design described above.

Both of these mixes were tested for both permeability as well as compressive strength. Although there were difficulties with the custom cylinders used for permeability testing, the mix was deemed adequate to proceed with construction of the large scale test project.



Full Scale Demonstration Project

Site Selection

Criteria for site selection included:

- Accessibility
- Acceptability to the landowner
- Indications of hydraulic conductivity
- Reasonable scale due to limited funding
- Location – Northern California

Numerous contacts were made with the water districts in the Northern California region including:

- Biggs-West Gridley Water District
- Butte Water District
- Levee District No. 1
- Plumas Mutual Water District
- Sutter Extension Water District
- Levee District No, 9
- Western Canal Water District

After numerous conversations with the water districts as well as various engineering firms, Mr. Paul Russell who is the manager and director of the Sutter Extension Water District confirmed that he had a potential site approximately 5 miles south of Gridley, California. He indicated that the levee had been documented with indications of hydraulic conductivity (seepage)

After visiting the site, it was preliminarily determined that this site had potential as a demonstration project. There was water in the adjacent canal. On the opposite side of the canal, there was a large “swamp” area with cattails, willows, and cottonwoods as well as an area of dead prune orchards.

The water district who owned the canal informed the CSU, Chico Research Foundation that the landowners of the orchards were the plaintiffs in the case of *Peekema Bros. v. Butte Water District and the Sutter Extension Water District*, Butte County Superior Court Case No., 119687. The Peekema suit alleged that water seepage from the canal through the levee was causing soil saturation in the orchard resulting in poor fruit yield and/or death to the orchard trees. The landowner (Peekema) had installed some monitoring wells along the canal and had documented the correlation between the water in the canal and the degree of saturation of the soil in the orchard. Indemnification (hold harmless) agreements were obtained from both parties in the litigation and site subsurface investigations were conducted.

In July, 1998, three soil borings were conducted on the crown of the levee. The soil borings were supervised by the independent testing lab, Vector Engineering and soil classifications were obtained using the Standard Penetration Test. Samples indicated that the levee was constructed of clay with thin layers of silt and sand. Based on the N-values of the Standard Penetration Tests, it was determined that a thirty foot deep wall should prevent any hydraulic conductivity between the canal and the adjacent orchard.

Permitting for the Project

Prior to commencing construction, all environmental and construction permits had to be addressed including:

- California Environmental Quality Act (CEQA)
- California Department of Water Resources (DWR) Reclamation Board Permit
- California Department of Fish and Game (DFG) 1600 Agreement
- US Army Corps of Engineers (USACOE) 404 Permit

Contractor Selection

It was determined that there were sufficient information in the plans and specifications to put the project out to bid as a lump sum fixed price contract. Prior to issuing bid documents, the CSU, Chico Research Foundation project team issued a Contractor Prequalification form to ensure that only qualified bidders would submit a price for the project.

The process revealed two contractors who were experienced in Slurry Cutoff Walls in the region. Inquip Construction, and Geo-Con Construction. Fixed price bids were received and Inquip was the lowest responsive, responsible bidder.

A fixed price contract for \$243,000 was awarded to Inquip Construction.

Construction Process

The contractor mobilized the project on June 12, 1999. The process of setting up temporary power, bentonite mixing tanks, and the HDPE slurry supply pipe took approximately five working days. Excavation of the cutoff wall commenced on June 17, 1999. The equipment utilized included:

- 2 Caterpillar excavators – One at each end of the trench. The lead excavator was digging the trench and the second excavator was mixing and placing the Soil-Cement-Bentonite-Tire mix for backfill.
- 1 Caterpillar Integrated Tool Carrier (ITC) – This piece of equipment served many purposes. With its interchangeable components, it can serve as a forklift to offload cement and bentonite from the delivery trucks. The ITC can also attach a front end bucket to serve as a loader, and a boom which allowed carrying heavy loads. The primary function of the ITC was to deliver cement to the mixing bin.
- 1 Caterpillar 953 Track Loader – The track loader is similar to a rubber tired front end loader only it is mounted on tracks for traction and flotation. The track loader was used to load soil and tire chips into the mixing bin. Once all materials were measured and

placed into the mixing bin, the front end loader would agitate the materials to mix them prior to placement.

- 1 – 6” contractors pump – the pump was used to supply water to the bentonite hydration and mixing tanks. The water was supplied from the canal which is fed from the Feather River.



QA/QC

The process of QA/QC was dictated by the USACOE specifications. All requirements were followed and documented. Slump, Permeability, and Compressive Strength were all measured as required by specification. As an observation, it should be noted that compressive strength testing was very unique due to the tire content. Unlike concrete, the samples failed at a low compressive strength however their volume typically rebounded due to the plastic behavior of the tires.

Lessons Learned

While the project outcome is considered successful, there are a few items which could be improved upon should this process be replicated. The following are a few suggestions which could improve the process of utilizing recycled tires in a slurry cutoff wall.

1. Tire delivery and mixing – On this project, the tires were delivered using a typical lumber chip truck with a moving conveyor floor. The trucks arrived at the site, opened up the rear doors, and the chips were dumped into a pile near the worksite. The track mounted loader (Caterpillar 963) then measured the proper number of bucket loads and moved them into the mixing bin. Upon completion of the project, there were significant numbers of tire chips in and around the site which were required by the Department of Water Resources Inspector to be cleaned up. The recommendation would be to have the

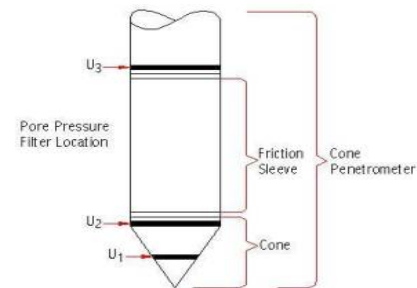
tires measured at the chipping facility and placed in bags or bins for placement into the mixing bin.

2. Backfill – It is suggested that the trench, not be backfilled to the upper limit. If the trench is backfilled to the top and the road is reconstructed, there are tire chips sticking out of the finished cutoff wall. It is suggested that the backfill be held to approximately one foot below the crown of the finished roadway. Clay soil could then be used in the top one foot of the wall with aggregate base on the finished surface.

Monitoring

Post Project Preliminary Monitoring

Upon completion of the project, and during reconstruction of the levee road, a Caterpillar 613 scraper encountered “soft” soil at the very north end of the project near the apron at Chandon weir. The scraper sunk into the soil to a depth of approximately three feet. This caused significant concern to the Department of Water Resources. At this time, a Cone Penetrometer test was performed on the cutoff wall. The Cone Penetrometer test is a method of probing vertically into a soil medium and measuring the tip resistance. Given a large enough sample, this test would indicate if any voids exist in the cutoff wall. Simply stated, if there was a void in the cutoff wall, the tip resistance would be significantly reduced. No such drop in resistance was found. Conversely, a significant problem with the apron at the Campbell weir was found. There were large voids behind the apron and it became apparent that water has scoured the soil behind the apron. This coincides with the data indicating that water appears to be migrating through the levee at the north end of the project (monitoring well number 1) faster than at any other location.



Methods of Periodic Monitoring

Upon completion of construction, nine monitoring wells were installed at the site. Eight of wells were equidistant at the toe of the levee (parallel to the cutoff wall) and one additional well was installed in the middle of the existing swamp. Water level measurements were taken weekly using a water level sounder. The water level sounder is a device in which a probe is dropped into the well. The probe is attached to a flexible wire which has a tape measure engraved. When the probe encounters the water surface an audible sound is heard and the depth can be measured from the top of the well.



Using a known benchmark, the tops of the wells were then converted into real elevations using common surveying methods. A Topcon GTS-310 Total Station was utilized. The known elevation is DWR benchmark FR-47 located on Chandon Weir which is approximately 1,000 feet downstream from the project. The elevation of FR-47 is 91.395 USACOE 1991 datum.

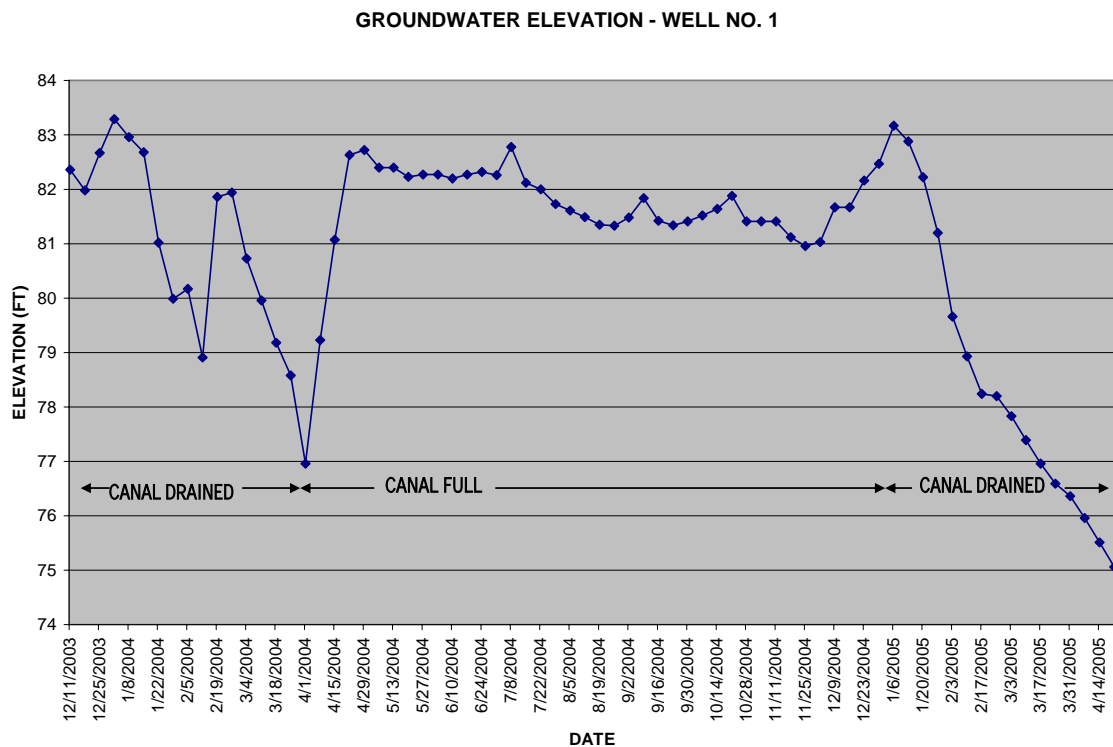
Using this data and the topographic survey conducted, the tops of the wells were found to have the following elevations:

Well Elevation Data

Well Number	Elevation (ft)
1	89.16
2	89.36
3	89.30
4	88.72
5	87.78
6	89.50
7	90.96
8	92.08
9	82.10

Results of Periodic Monitoring

After two years of weekly readings, it was readily determined that there is a correlation between the draining of the canal and the groundwater level on the opposite side of the cutoff wall. Similarly, the filling of the canal showed an increase in the groundwater. A sample graph is shown below. The remaining graphs are included in Appendix C. The data proved similar for all of the wells. In short, when the canal is filled, the groundwater rises in the adjacent property. Similarly when the canal is drained, the groundwater lowers. What was unclear is whether the water was going around, under, or through the cutoff wall.



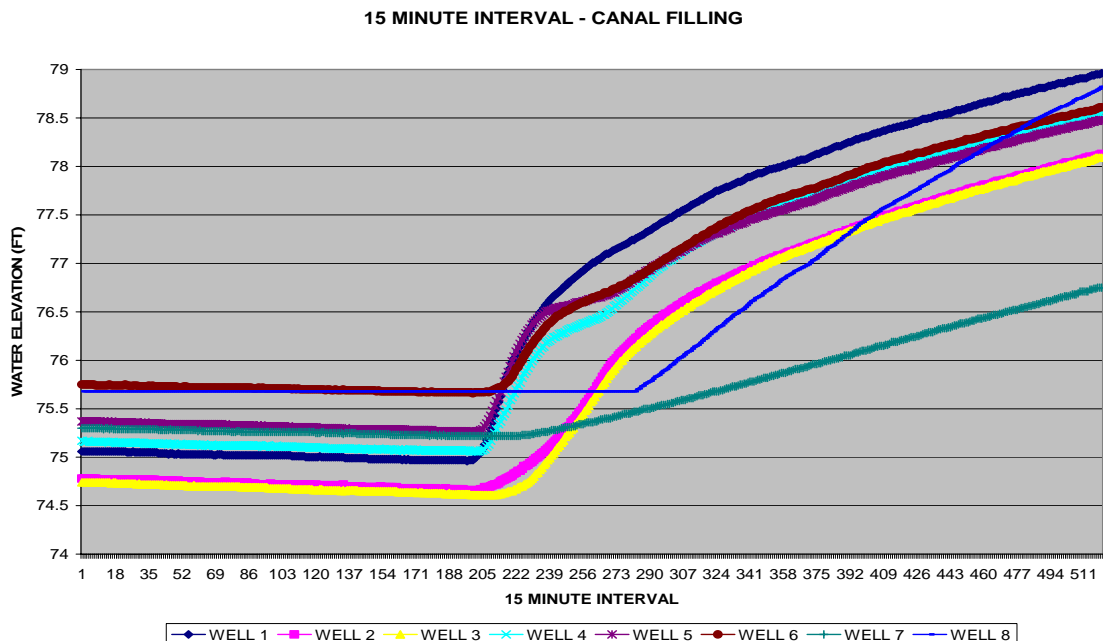
Secondary Monitoring Method

To answer the question of how the water was migrating from the canal to the adjacent field, a water level data logger was installed in each well prior to the canal being filled in April, 2005. The logger used was a WL-15X Water Level Logger produced and distributed by Global Water Instrumentation, Inc. The water level data logger is a device installed into the well and programmed to take elevation readings at a given time interval. For this project, the data loggers were programmed to take elevation readings every 15 minutes for a two week period. The loggers were installed on Friday, April 22, 2005 and retrieved on Friday, May 6, 2005. The Joint Board Water District began filling the canal on Monday, April 25, 2005.



Results of Secondary Monitoring Method

On May 6, 2005, two weeks of “real time” monitoring data was downloaded from the data loggers. The water levels in the wells increased when the canal was filled. The question was not whether the water levels would rise but more importantly would they increase equally (indicating a cutoff wall failure) or would the water level rise at each end (or one end) indicating that the water was making an “end around” on the cutoff wall. It is important to note that the Joint Water Board has had significant problems with the levee and is currently making repairs in other locations. There was suspicion on the part of the CSU, Chico Research Foundation representatives that the water was coming through the levee at the north end of the project. The north end of the project is adjacent to the Campbell Weir. Just downstream of the weir is a concrete apron that appears to be eroded. There are visible signs of voids behind the apron which were caused by scour from the water moving through the weir and the associated eddy currents. The following chart is an indication of how the water level changed during the first week after the canal was filled. Additional charts are provided in Appendix C.



Summary

Five years has elapsed since the completion of the Recycled Tire Levee Slurry Cutoff Wall Demonstration project. While the cutoff wall has met the laboratory specifications there are still many questions including:

- Is the cutoff wall functioning?
- Is the cutoff wall deep enough?
- Is the water migrating around the ends of 1400 lineal feet cutoff wall?
- Is the recycled tire integration feasible from a cost perspective?

With respect to the wall function, the data is promising. There is sufficient data to opine that the water is migrating around or under the cutoff wall (see appendix C). The cutoff wall construction process was not affected by the incorporation of recycled tires. The concerns of tire flotation were not encountered in the construction process due to the viscosity of the backfill material and solidification over time.

While analyzing the cost is difficult, it is recognized that the project used approximately 475 tons of tires. Assuming that these tires could be produced at a cost of \$20-\$25 per ton and that trucking to the north state would cost approximately \$300 per truckload, the increased cost of construction to this levee project would be approximately \$20,000. While this cost may seem significant the unit cost of this is very insignificant.

At the time of construction of the Levee Slurry Cutoff Wall Demonstration Project, the USACOE was experiencing a typical cost of \$6.00 per square feet. Since this project was 1400 lineal feet long and 28 feet deep, this equates to 39,200 square feet. Assuming that a similar project could be constructed, the increased cost of incorporating recycled tires would be:

$$\frac{\$20,000}{39,200\text{lf}} = \$0.51 \text{ per square foot or an increase of } 8.5\% \text{ (as compared to } \$6 \text{ per lf)}$$

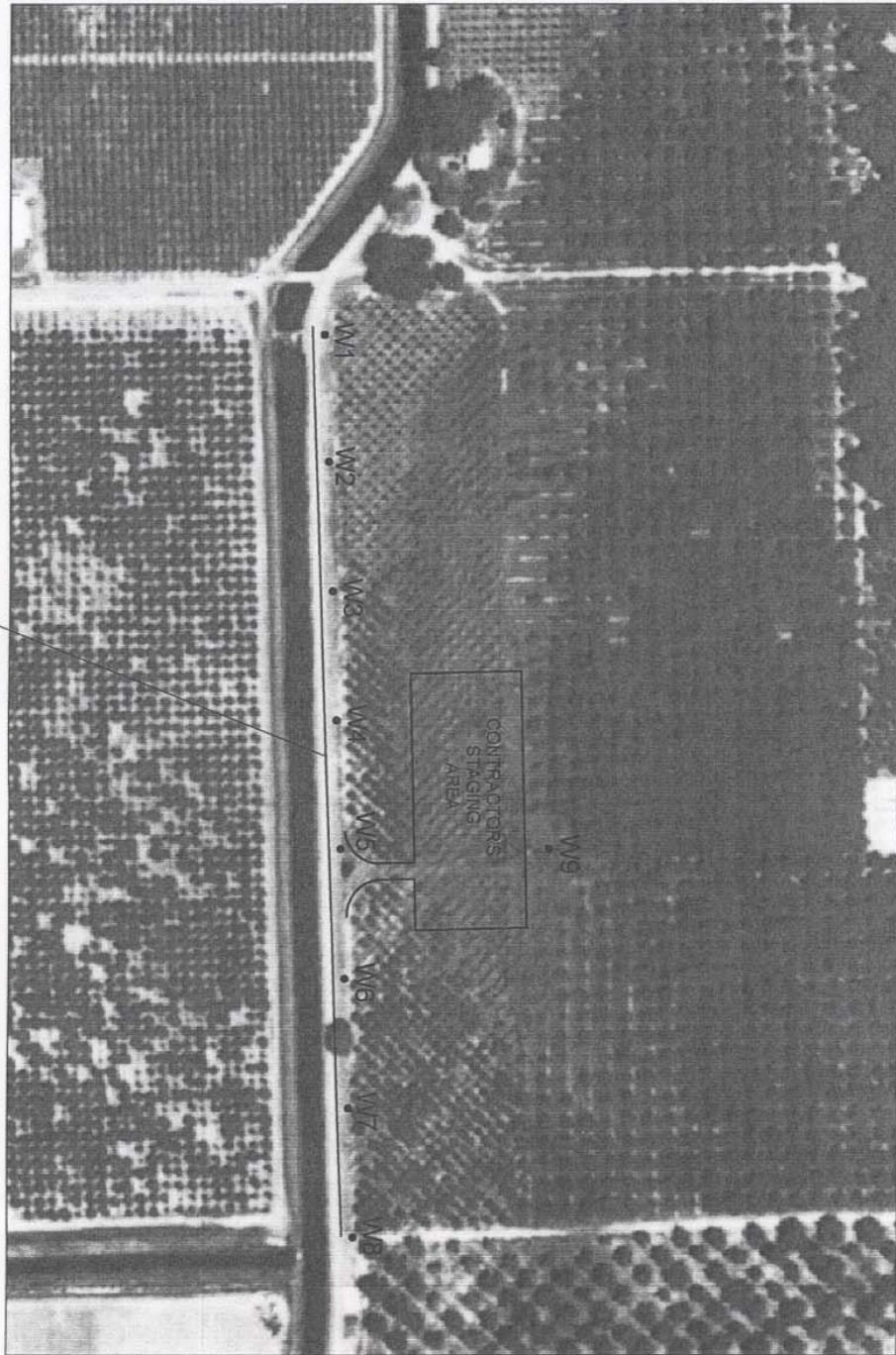
Conversely, if 25 miles of cutoff wall was constructed each year and the average depth was 40 feet, this would equate to 5,280,000 square feet of cutoff wall constructed. Using the average tire usage from the Recycled Tire Levee Cutoff Slurry Wall Demonstration Project, it is reasonable to consider that 63,980 tons of tires per year could be disposed. 63,980 tons of tires equates to approximately 6.4 million tires per year.

Abbreviations and Acronyms

CIWMB:	California Integrated Waste Management Board
DWR:	California Department of Water Resources
DFG:	California Department of Fish and Game
F _c :	28 Day compressive strength
S-C-B:	Soil-Cement-Bentonite Slurry Cutoff Wall
S-C-B-T:	Soil-Cement-Bentonite-Tires Slurry Cutoff Wall
USACOE:	United States Army Corps of Engineers

Appendix A

Project Plans



CUTOFF WALL

OF 1 SHEETS
SHEET 1



RECYCLED TIRE CUTOFF WALL DEMONSTRATION PROJECT

The California Integrated Waste Management Board
The Research Foundation at California State University, Chico

Appendix B

Project Specifications

SECTION 02330

SLURRY CUTOFF WALL

1. **SCOPE:** The work covered by this section of the specifications consists of furnishing all plant, labor, equipment, and materials and of performing all operations in connection with the construction of a slurry cutoff wall, in accordance with these specifications and applicable drawings. Shredded rubber for backfill to be supplied by California State University Research Foundation.

2. **APPLICABLE PUBLICATIONS:** The following publications of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent referenced.

2.1 American Petroleum Institute (API) Standard Specifications:

API RP 13B-1 (1990; 1st Ed) Recommended Practice Standard Procedure for
Field Testing Water-Based Drilling Fluids

API SPEC 13A (1993; 15th Ed) Specification for Drilling-Fluid Materials

2.2 American Society for Testing and Materials (ASTM Standards):

ASTM C 143 (1990a) Slump of Hydraulic Cement Concrete

ASTM C 150 (1994) Standard Specification for Portland Cement

ASTM D 422 (1994) Standard Test Method for Particle Size Analysis of Soils

ASTM D 2487 (1994) Standard Classification of Soils for Engineering Purposes

ASTM D 4318 (1993) Standard Test Method for Liquid Limit, Plastic Limit, and
Plasticity Index of Soils

ASTM D 698 (1991) Laboratory Compaction Characteristics

ASTM D 1556 (1990) Standard Test Method for Density and Unit Weight of Soil
in Place by the Sand-Cone Method

ASTM D 4832 (1988) Preparation and Testing of Soil-Cement Slurry
Test Cylinders

2.3 U.S. Army Corps of Engineers Publications:

EM 1110-2-1906 (1970) Laboratory Soils Testing
Appendix VII

3. GEOTECHNICAL SITE CONDITIONS:

3.1 Exploration Borings: Subsurface exploratory borings have been obtained by the California State University Research Foundation. Logs of explorations are included in the contract documents. The borings show the subsurface soil conditions and groundwater encountered at the time of drilling.

3.2 It is the Contractor's responsibility to become acquainted and satisfied as to the character, quality, and quantity of surface and subsurface materials by inspecting the sites and by evaluating information derived from the exploratory work that may have been accomplished by others or included in these Contract Drawings. Any failure by the Contractor to become acquainted with all the available information will not relieve him from responsibility for properly estimating the difficulty or cost of successfully performing the work.

4 DEFINITIONS: The terms used in this section are defined as follows;

4.1 Slurry Cutoff Wall: The slurry cutoff wall is a 1.5-foot minimum width barrier installed below the prepared working surface using the slurry trench excavation method and backfilled with the approved slurry cutoff wall backfill as defined below, and capped with compacted fill as defined in subparagraph "Slurry Cutoff Wall Cap," to form a relatively impervious cutoff wall.

4.2 Slurry Cutoff Wall Cap: The cap is a gradually widened transition zone of compacted fill placed between the top of the slurry cutoff wall and the base of the pavement section.

4.3 Slurry: Slurry is a colloidal mixture of bentonite (fully hydrated) and water or other suitable material approved by the California State University Research Foundation Representative.

4.4 Bentonite: Bentonite is an ultrafine natural clay whose principal constituent is sodium cation montmorillonite.

4.5 Slurry Cutoff Wall Backfill: A homogeneous mixture of material produced by mixing soil, bentonite, cement, shredded rubber tires and water and/or other materials approved by the California State University Research Foundation Representative which is used to construct the slurry cutoff wall below the cap.

4.6 Groundwater Level: The groundwater level is the piezometric level of the groundwater as determined from piezometers and wells. There have been no wells installed for this project. The groundwater shown on the drill logs were groundwater levels at the time of drilling. The groundwater level can vary depending on river stage and season.

4.7 Working Surface: The working surface is the top of the prepared surface on the levee and as shown on the drawings.

5. **SUBMITTALS**: In accordance with SECTION 1305, SUBMITTAL PROCEDURES, the Contractor shall submit data for approval by the California State University Research Foundation Representative for the following items required by this section prior to the start of work unless otherwise indicated herein.

5.1 Schedule and Sequence of Operations: The schedule and sequence of operations shall include but are not limited to use of excavated material, waste management, slurry preparation, slurry placement, bottom cleaning, and backfill preparation and placement.

5.2 Slurry Trench Construction: The layout of operations for the construction of the slurry trench shall include but is not limited to drawings depicting the bentonite storage area, slurry preparation area, hydration ponds(s) slurry storage area, backfill storage and mixing area, location and sizes of all stationary equipment, water storage tanks, pumps, valves, lines, hoses, materials, and waste areas.

5.3 Equipment: Data on equipment to be used in the construction of the slurry trench and equipment to be used in the Contractor's quality control testing.

5.4 Bentonite certification

5.5 Cement certification

5.6 Backfill Mix Design Test Procedures

5.6.1 General: A design mix will be supplied to the contractor. The California State University Research Foundation reserves the right to modify the backfill mix design as required to meet hydraulic conductivity (permeability), compressive strength, and slump. The bid should be based on the following mix:

Component	% of Dry Wt.
Soil	67
Bentonite	3
Cement	5
Tire chips	25

5.6.2 This section not used.

5.6.3 This section not used.

5.6. This section not used.

5.6.5 This section not used.

5.6.6 Basis for Selection of the Backfill Mix Design:

This section not used.

5.7 Quality Control Testing Equipment and Procedures: The Contractor will submit for approval the methods to be used during construction for assuring the constituents of the approved backfill mix design properties, and bentonite slurry are continually met. This includes equipment and procedures for slump, and verifying the mix proportions of the soil, bentonite, cement, water, and any other approved constituents of the mix design are continually met.

6. MATERIALS:

6.1 General: The Contractor shall maintain at the jobsite a sufficient quantity of raw materials and other supplies such that the work can proceed uninterrupted by material shortages. The slurry and slurry wall backfill to be used shall be suitable for the project. The Contractor shall use the approved cutoff wall backfill design mix supplied by the California State University Research Foundation Representative.

6.2 Bentonite: The bentonite shall be a sodium cation base montmorillonite powder (Premium Grade Wyoming-type bentonite) that conforms to the standards set forth in API SPEC 13A, Section 4. The

Contractor shall furnish to the California State University Research Foundation Representative a certificate of compliance and a copy of the test reports from the bentonite manufacturer for each lot of bentonite shipped to the site stating that the bentonite complies with all applicable standards. No bentonite from the bentonite manufacturer shall be used prior to acceptance by the California State University Research Foundation Representative. All bentonite will be subject to inspection, sampling, and verification of quality by testing under the supervision of the California State University Research Foundation. Bentonite not meeting the specifications shall be promptly removed from the site and replaced with bentonite conforming to specification requirements at the Contractor's expense. Bentonite shall be protected from moisture during transit and storage.

6.3 Cement: Cement shall be Portland Cement Type I or Type II (per ASTM C 150). A written certification specifying cement quality shall be provided by the cement supplier and retained by the Contractor.

6.4 Water: The Contractor shall supply all water required for mixing with bentonite to produce slurry and slurry backfill. The water shall be clean, fresh, and comply with the standards set below:

- a. A pH equal to 7.0 plus or minus 1.0.
- b. Total dissolved solids not greater than 500 parts per million.
- c. Oil, organics, acids, alkali, or other deleterious substances not greater than 50 parts per million each.
- d. Hardness less than or equal to 50 ppm (Recommendation Only).

The canal at the work site is an acceptable source of water.

6.5 Admixtures: In the event the Contractor uses any additional admixture, it shall be subject to approval of the California State University Research Foundation Representative and the Contractor shall have on file a written statement as to the use of any such admixture, its effect on the slurry, its long-term stability, and its effect on the environment. Admixtures of the type used in the control of oil field drilling mud such as thinners, dispersants, and flocculants may be used to control standard properties of the slurry such as apparent viscosity and filtration characteristics subject to the approval of the California State University Research Foundation Representative. Peptizing or bulking agents shall not be mixed with the slurry.

6.6 Shredded Rubber Tire: Shredded Rubber tire will be supplied by the California State University Research Foundation. The approximate size of the tire chips will be capable of passing a 2" sieve. The tire chips will be delivered to the jobsite staging area by the tire processor. The haul vehicle will be an end dump truck.

6.7 Bentonite Slurry: The bentonite slurry for supporting the sides of the trench and that mixed with the backfill shall consist of a stable colloidal suspension of powdered, premium-grade natural bentonite in water. It is the responsibility of the Contractor that the slurry meets the necessary properties. The properties of the slurry used in all construction sequences shall be determined in accordance with the testing procedures described in API RP 13B-1 and shall conform to the following requirements:

6.7.1 Initial Bentonite Slurry Mixture: At the time of introducing bentonite slurry into the trench excavation, the slurry mixture shall have a minimum apparent viscosity of 40 seconds as measured by the Marsh funnel. The slurry density shall be a minimum of 64 pounds per cubic foot. The water loss shall not be greater than 20 cubic centimeters in 30 minutes as measured by a filter press at 100 psi. Mixture adjustments shall conform to the requirements in paragraph "ADDITIONAL BENTONITE."

6.7.2 Trench Bentonite Slurry Mixture: The minimum apparent viscosity of the bentonite slurry mixture in the trench at any time shall be 40 seconds as measured by the Marsh funnel. The density of the slurry in the trench at any level shall be between 64 and 85 pounds per cubic foot. The water loss shall not be greater than 20 cubic centimeters in 30 minutes as measured by the filter press at 100 psi. Mixture adjustment shall conform to the requirements in paragraph "ADDITIONAL BENTONITE."

6.7.3 Additional Bentonite: If directed by the California State University Research Foundation Representative, the Contractor shall thicken the slurry to a more viscous condition than the limits specified above. The Contractor shall use additional bentonite, as directed.

6.8 Soil: Soils obtained from the cutoff wall construction, imported material, or combination thereof, for use in the slurry cutoff wall backfill, shall contain no material sizes larger than 3 inches in diameter and shall be free of roots, debris, and other deleterious material that may adversely affect the properties of the backfill. The Contractor is responsible for changes in the chemistry of soils used in the slurry wall cutoff construction and its effect on the desired properties of the backfill.

6.9 Slurry Wall Backfill: The slurry wall backfill mix shall conform to the design as stated in Section 5.6.1. However the California State University Research Foundation and contractor will cooperate in modifying the mix, if necessary, to improve workability. The Intent of the Research Foundation is to verify the viability of a mix incorporating waste tire chips. The goal is for the mix to meet permeability and strength requirements while maximizing the quantity of tire chips used. All backfill shall be free of roots and other deleterious materials.

6.9.1 Testing: The backfill mix will be sampled at least every 300 ft. of wall or when any changes are made to the backfill mixing operation. The California State University Research Foundation will be responsible for all testing of the backfill mix. Plastic molds shall be used to cast the mix specimens. The molds will be twelve-inch diameter by twelve -inch long test cylinders for permeability tests and twelve-inch diameter by twenty-four-inch long test cylinders for strength tests. The wet samples will be poured into the molds and rodded or vibrated to remove trapped air pockets and then sealed. The specimens will be stored in a constant temperature, damp environment, positioned on porous stones with filter paper to allow for drainage during the curing period, until tested or otherwise directed by the California State University Research Foundation Representative.

6.9.1.1 Compressive Strength Testing: Two test specimens from each sampled batch will be subjected to unconfined compressive strength testing (ASTM D4832-88). One of the samples will be tested after curing for fourteen (14) days, and one after curing for twenty-eight (28) days.

6.9.1.2 Permeability Testing: One test specimen from each sampled batch will be subjected to permeability testing. The sample will be tested in accordance with the requirements prescribed in EM1110-2-1906, Appendix VII, Back Pressure Method.

The permeability test parameters to be used are as follows:

- Average Effective Confining Stress: 10 psi
- Hydraulic Gradient: 15
- Permeate: Canal water near the site
- Backpressure: Sufficient to ensure a Skempton's pore pressure "B" parameter greater than or equal to 0.95.

Permeability tests will be performed on the same sample after 14 days and 28 days.

6.9.2 Basis for Selection of the Backfill Mix Design: The mix design has been selected based on the results of the a trial mix design program performed by California State University Research Foundation. The following parameters have been used as the basis for the selection of the mix design.

Permeability (28-day)	5X10-7 cm/sec (maximum)
Compressive Strength (28-day):	15 psi (minimum)
	200 psi (maximum)
Slump	4 to 6 inches

6.10 Material Storage Facilities: The Contractor shall provide all necessary materials, equipment and personnel to store bentonite, cement and other additives under conditions to prevent moisture or other contaminants from mixing with the materials prior to use in the slurry plant.

7. EQUIPMENT:

7.1 General: The Contractor shall furnish all necessary plant and equipment for efficiently stripping, cutting, and/or filling to form the slurry-mixing and equipment-operating surface; excavating the trench; mixing and placement of backfill; disposal of undesirable excavated material in accordance with other provisions of this contract; and, preparation for and placement of the impervious cap on the completed trench, and for testing of the materials used in such process. The Contractor shall obtain and maintain at the jobsite a supply of spare critical replacement parts or backup equipment sufficient to allow the slurry cutoff wall construction to proceed with minimum loss of time due to mechanical breakdown or equipment failure.

7.2 Equipment Weight, Speed, and Width: Weight of equipment to be used on the levee crown shall be limited to a maximum gross loaded axle weight of 16,000 pounds, and a maximum track vehicle weight of 2,500 pounds per square foot. The maximum operating speed of all equipment used on the levee crown roads shall be 15 mph. The maximum overall width of equipment used on the levee shall be limited to 18 feet.

7.3 Cutoff Wall Construction: Trench excavation equipment for excavating the slurry trench shall be any type of earth moving machinery capable of performing the indicated work on the drawings and/or as specified herein. The equipment shall be that which reduces live-load surcharge to a level that will produce no significant contribution to the instability of the trench. Regardless of the equipment type used, it shall be capable of excavating to the required depth and width of the trench in a single pass of the excavating equipment. If a dragline bucket is used, it shall be a heavy duty model with no protrusions along the sides of the bucket for drag or hoist chains extending beyond the limits of the cutter teeth.

7.4 Mixing and Delivering Slurry: Slurry mixing and placing equipment will be approved by the California State University Research Foundation Representative. The slurry mixing plant shall be a colloidal batch or continuous mixing plant. It shall include the necessary equipment, including a mixer capable of producing a stable colloidal suspension of slurry or other mix combinations approved by the California State University Research Foundation Representative. It shall include pumps, valves, hoses, supply lines, tools, and other equipment and materials required to adequately supply slurry to the slurry trench. Tanks for storage of hydrated slurry shall be mechanically or hydraulically agitated.

7.5 Mixing and Placing Backfill: The equipment used for the mixing and placing of the backfill material, including but not limited to bulldozers, disks, harrows, motor patrols, pugmills and haul trucks shall be capable of mixing backfill materials into a homogeneous mixture conforming to the contract requirements and be suitable for placement of the backfill material in the trench as specified herein. Initial placement of backfill on the trench bottom shall be by clamshell or other approved method and shall prevent free fall, segregation, and entrapment of slurry.

7.6 Retaining Berms: Suitable grading and earth-moving equipment shall be available for preparing the work area for slurry cutoff wall installation including equipment for the construction of slurry spill retainment berms or ditches.

7.7 Hauling Equipment: Hauling equipment shall consist of pneumatic-tired vehicles having dump bodies suitable for dumping.

7.8 Cleaning of Slurry: Slurry cleaning equipment shall include but not be limited to a vibrating shaker screen, centrifugal sand separator, and/or stilling ponds.

8.0 LEVEE PREPARATION:

8.1 The Contractor shall prepare the working surface of the levee section to a firm and essentially level condition for passage of the Contractor's machinery and equipment as shown on the drawings. A berm or other appropriate type of barrier shall be constructed to prevent off-site movement of waste materials, slurry spills, etc.

8.2 The Contractor shall provide, install, and maintain all layout and necessary construction staking to locate the cutoff wall within the Range of Allowable Cutoff Wall Installation shown on the contract drawings. The contractor shall submit a staking plan which identifies the station and location to provide accurate locations and to ensure that the levee elevation is returned to its current elevation. A system for locating stations along the cutoff wall alignment and relating them to the plans shall be established by the Contractor and submitted to the California State University Research Foundation Representative for approval.

9.0 SLURRY CUTOFF WALL CONSTRUCTION:

9.1 General: The slurry cutoff wall as placed shall be homogeneous and shall be constructed to the elevations, lines, grades, and cross-section shown on the drawings and in accordance with these specifications, unless otherwise directed by the California State University Research Foundation Representative. The slurry cutoff wall shall be constructed to the following dimensions using the approved backfill mix design and procedures:

Width:	18-inch minimum
Depth:	28 feet below crown of levee
Mix Design:	As supplied by the California State University Research Foundation

Representative (See Paragraph 5.7.1- BASIS FOR SELECTION OF THE BACKFILL MIX DESIGN)

Final acceptance of the cutoff wall will be based on quality control testing of the backfill material. Any installed material not in compliance with the accepted backfill mix design shall be removed and replaced by the Contractor at his own expense. The California State University Research Foundation may modify the dimensions and quantities of the work as determined necessary. The Contractor shall submit a general work sequence schedule and layout plan of operations to the California State University Research Foundation Representative for approval ASAP after contract award and a minimum of 3 calendar days prior to the start of construction.

9.2 Working Surface: The working surface from which the slurry cutoff wall is to be constructed shall be as defined in paragraph "DEFINITIONS," and shall constitute the top of the slurry cutoff wall cap for the purpose of measurement for payment. However, the Contractor may construct, at no additional expense to the California State University Research Foundation, a working surface to a level no more than

eighteen (18) inches lower than the existing levee crown for his own convenience. There will be no payment for any additional excavation, fill, relocation, or slurry cutoff wall required as the result of constructing a lower level working surface than the defined working surface. Upon completion of the slurry cutoff wall installation, the levee shall be restored to final alignment and grade. Material excavated for the purpose of constructing a lower working surface may be reused to replace the top of the levee. The compaction and testing requirements for the replaced levee material shall be the same as described in paragraph "SLURRY CUTOFF WALL CAP." The Slurry Cutoff Wall Cap shall then be constructed as described in paragraph "SLURRY CUTOFF WALL CAP."

9.3 Blasting: Explosives shall not be used in connection with this contract.

9.4 Excavation: The excavation shall be by the slurry method. Excavation shall be conducted in a manner which provides for a continuous 1.5-foot minimum width trench to the required depth at all points along the centerline of the excavation. The Contractor shall excavate the slurry trench from the working surface. The excavation shall be carried immediately to the minimum depth shown on the drawings at the point where excavation is started. The California State University Research Foundation Representative may direct the Contractor to deepen the trench based on examination of the bucket cuttings. The toe of the slope of the trench excavation shall not precede the toe of the backfill slope by less than 50 feet or more than 150 feet. The slurry trench shall be constructed without undue interruption until complete. If extended delays in backfill operation occurs for any reason, the California State University Research Foundation Representative may require reexcavation of the placed backfill. If required, this reexcavation shall consist of the removal of 5 feet perpendicular to the slope of the backfill for the full depth of the slurry trench. That section of the slurry trench backfill material that is removed and rebackfilled shall be considered incidental to the slurry trench cutoff pay item.

9.5 Placement of Slurry: The slurry shall be introduced into the trench at the time excavation begins. The level of the slurry in open trenches shall be at all times maintained a minimum of 2 feet above the groundwater level and between 6 and 18 inches below the working surface until the placement of backfill material is complete. The Contractor shall have sufficient personnel, equipment, slurry storage areas, and stored slurry materials ready to raise the slurry level at all times in the excavated trench during construction within the limitations specified in paragraph "SLURRY CUTOFF WALL CONSTRUCTION" and subparagraphs thereof. To this end, the Contractor shall have personnel on call to raise the slurry level at any time this occurs, weekends and /or holidays included. Dilution of the slurry by surface waters shall be prevented. The quality of the slurry shall be maintained at all times, including periods of work stoppage, in a condition which meets the requirements set forth in paragraph "BENTONITE SLURRY." Conditioning of the slurry may require recirculation through shaker screens or the addition of approved additives.

9.6 Excavated Material: Material excavated from the trench meeting the requirements of paragraph 6.8 Soil, may be used in the backfill. Material not used in the backfill shall become the property of the Owner. Contractor to evenly spread excess soil over the contractors laydown area as directed by the California State University Foundation Representative.

9.7 Stability: The Contractor shall be responsible for insuring and maintaining the stability of the excavated trench at all times for its full length and depth and shall be responsible for maintaining slurry

densities and levels within specified limits. The Contractor shall control surcharges from all excavation and backfilling equipment, waste, berm construction, backfill stockpiles, and any other loading situations that may affect trench stability. It is the Contractor's sole responsibility to ensure that the mixing of backfill and any stockpiles do not affect the open trench stability. In the event of failure of the trench walls prior to completion of backfilling, the Contractor shall at his expense reexcavate the trench and remove all material displaced into the trench and take corrective action to prevent further deterioration.

10. BACKFILLING:

10.1 Mixing Areas: Areas for mixing of backfill, preparing compacted fill for the slurry cutoff wall cap, and other operations shall be located within designated staging areas shown on the contract drawings or within areas approved by the California State University Research Foundation Representative. All mixing areas shall be cleaned up and restored upon completion of the work in accordance with paragraph "CLEANUP."

10.2 Mixing: Stockpiled material generated during slurry cutoff wall installation and/or material from borrow or commercial sources shall be mixed and blended by approved methods. The backfill material shall be thoroughly mixed into a homogeneous mass, free from large lumps or pockets of fines, sand, or gravel. Occasional lumps of up to four (4) inches in their largest dimension will be permitted. The backfill material shall have a consistency as approved by the California State University Research Foundation Representative. The backfill material, just prior to placement in the trench, shall have a consistency to provide a slump of from 4 to 6 inches per ASTM C 143 . Any damage to the slurry cutoff wall as a result of operating equipment near the wall or for other reasons shall be repaired or restored by the Contractor at no additional cost to the California State University Research Foundation.

10.3 Placement: The backfill material shall be placed in the excavated trench in such a manner that no pockets of slurry are trapped in the completed slurry trench. The Contractor shall backfill continuously from the beginning of the trench in the direction of the excavation to the end of the trench. Placing operations shall proceed in such a fashion that the top of the backfill below the surface of the slurry shall follow a reasonably smooth grade and shall not have hollows which may trap pockets of slurry during subsequent backfilling. To this end, the face of the backfill below the surface of the slurry may require rodding, and the Contractor shall have such equipment available at the job site. Free dropping of backfill material through the slurry will not be permitted. Initial backfill shall be placed by lowering it to the bottom of the trench with crane and clamshell bucket until the surface of the backfill rises above the surface of the slurry trench at the end of the trench. Backfill shall then be placed in such a manner that the backfill enters the trench by sliding down the forward face of the previously placed backfill. To accomplish this, the Contractor shall backfill from the initial backfill toward the opposite end of the trench. Backfilling operations shall proceed in such a manner that the slope of the initial backfill will be maintained. The new backfill material will be allowed to slide down the slope of the previously placed backfill and shall be placed in such a manner that pockets of slurry will not be trapped during the backfilling. This remaining backfill may be accomplished by the use of bulldozer or other approved equipment and in such a manner that the backfill below the slurry surface will be pushed along the trench.

10.4 Mixing and Placing During Cold Weather: No mixing or placing of the backfill shall be performed when the air temperature is below 32 degrees F. Frozen backfill shall not be placed in the slurry trench.

11. **SLURRY CUTOFF WALL CAP:** The slurry cutoff wall cap shall have compacted fill material placed to the lines and grades shown on the drawings. After the cutoff wall has been topped off and the slurry has set, but before drying can occur, the cutoff wall shall be capped with compacted fill in accordance with the details shown on the drawings. Any settlement of compacted fill over the cutoff wall shall be backfilled with compacted fill. The cutoff wall cap material shall classify as a (CL), (CL-ML) or a (SC) or (SM) with a minimum of 20 % fines content. The material shall be compacted to a dry density of at least 95 percent of maximum density and at a moisture content within 2 percent of the optimum moisture content. At least one compaction test (ASTM D 698), one field density test (ASTM 1556), and one soil classification test (ASTM D 2487 and ASTM D 4318) shall be performed for each 1,000 lineal feet of slurry wall cap. After the compacted fill has been properly placed and compacted at the top of the slurry cutoff wall, the levee crown shall be restored in accordance with SECTION: "AGGREGATE BASE COURSE" and where required on the drawings, SECTION: "BITUMINOUS COURSE."

12. **CLEANUP:** The Contractor shall continually clean up slurry wastes, debris and leftover materials resulting from the cutoff wall construction process. After completion of the work, the site shall be cleared of all debris which may have accumulated in the execution of the work. The Contractor shall be responsible for disposal of waste materials in accordance with all Federal, State, and local regulations and codes, such as the Clean Water Act and the National Historic Preservation Act.

13. **DISPOSAL OF WASTE MATERIALS:** Spoil generated by the cutoff wall construction shall become the property of the Contractor and shall be disposed of off-site, in accordance with all State, Federal and local regulations and codes, such as the Clean Water Act and the National Historic Preservation Act.

14. **QUALITY CONTROL TESTING:** The Contractor shall be responsible for project quality control records. Observation, measurements, and tests described in these specifications shall be performed for quality control. All quality control records, routine testing procedures, observations, and measurements shall be available for inspection by the California State University Research Foundation Representative's Representative at any time.

14.1 Bentonite: The Contractor shall submit in accordance with Section 01305 (Submittal Procedures), a certificate of compliance with the specifications from the bentonite supplier for each truck load of bentonite delivered to the site. The bentonite shall be tested in accordance with Section 4 of API SPEC 13A to confirm conformance with the physical requirements listed in Table 4.1 of Section 4.

14.2 Water: This section not used.

14.3 Slurry Properties: All tests specified in this paragraph shall be conducted in accordance with API RP 13B-1. The bentonite slurry shall be tested prior to placing the slurry in the trench a minimum of 2 times each working day. The following tests shall be performed: viscosity, filtration, and density. At the time of placing backfill into the slurry-filled trench, the bentonite slurry within the trench shall be tested for viscosity, filtration, and density. The bentonite slurry in the trench shall be sampled a minimum of 2 times each working day, 1 each at a depth of 10 feet and 20 feet, both within 50 feet of the advancing toe of the fill and a third sample taken within 5 feet of the toe of the backfill. The sampling devices used to collect samples will be subject to approval of the California State University Research Foundation Representative. The Contractor shall be required to obtain additional samples for the California State University Research Foundation Representative at any time or location requested. Personnel shall be provided by the Contractor for conducting the tests and they must have a working knowledge of test procedures for drilling fluids in accordance with applicable API standard procedures. Equipment for bentonite slurry testing shall be furnished and maintained by the Contractor.

14.4 Cutoff Wall Measurements: Prior to backfill operations and for every 10 feet along the cutoff wall centerline, the Contractor shall profile the entire depth of trench excavation using devices approved by the California State University Research Foundation Representative to ensure the minimum width of wall is placed during the backfilling operation.

14.5 Backfill Slope: Upon request of the California State University Research Foundation Representative, the backfill slope shall be determined by sounding the depth of the wall at horizontal intervals of 10 feet.

14.6 Soil Gradation: A representative sample of the soil being used in the backfill shall be taken every 300 lineal feet of trench and a complete soil classification performed in accordance with requirements of ASTM D422. These tests will be the responsibility of the Research Foundation.

14.7 Slump Tests: The slump of the backfill shall be tested in accordance with ASTM C 143. Slump cone tests shall be performed at equally spaced intervals throughout each construction day that backfill is being placed.

14.8 Backfill Mix Proportions: Backfill samples shall be collected and tested for every 300 feet of wall or when mixing operations change.. Records of the backfill mix proportions shall be maintained by the Contractor. These records shall be made of the percent by water, dry weight of the soil, bentonite,

cement, and any other approved additives utilized. Any approved adjustments in the bentonite mix shall also be recorded.

15. **RECORDS:** Records shall be maintained by the Contractor for all testing, measurements, and inspections performed to ascertain that the cutoff wall construction meets the specifications. Required reports, records, and documentation shall be furnished to the California State University Research Foundation Representative daily. The Contractor's required records are outlined below.

15.1 As-Built Profile: An as-built profile of the trench bottom, backfill slope including descriptions of materials encountered in the trench bottom shall be continuously maintained by the Contractor. This profile shall indicate extent of excavation and the backfill profile at the end of each work day, as determined from the soundings. The Contractor shall furnish records of all observations, measurements, and tests performed, identified with the location and time of testing. These records shall be furnished no later than 24 hours after the tests, measurements, and/or observations were made.

15.2 Results: The results of all construction control testing required in these specifications, including water tests, slurry tests, backfill tests, and depth of soundings shall be furnished by the Contractor. The Contractor shall furnish records of all observations, measurements, and tests performed, identified with the location and time of testing. These records shall be furnished no later than 24 hours after the tests, measurements, and/or observations were made.

15.3 Construction Log: The Contractor shall maintain a construction log of daily activities which shall include delays encountered during construction, causes of delays, locations of affected areas, and extent of delays. The log shall also record unusual conditions or problems encountered, and the dispositions made. The Construction log is to be submitted to the California State University Research Foundation Representative at the end of each shift.

16. **QUALITY ASSURANCE:** The California State University Research Foundation may collect and perform quality assurance testing on the bentonite slurry and slurry wall backfill materials. The California State University Research Foundation testing will in no way relieve the Contractor of the responsibility of performing tests necessary to meet the construction requirements. All routine testing procedures being conducted by the Contractor shall be available for inspection by the California State University Research Foundation Representative at any time.

17. **MEASUREMENT:** Measurement for Slurry Cutoff Wall, shall be based on the area in square feet of wall measured in a vertical plane through the centerline of the slurry cutoff wall within the boundaries established by the working surface as defined in DEFINITIONS, the bottom of the slurry cutoff wall and vertical lines at each end of the slurry cutoff wall. Measurement shall be based on surveys and measurements taken at the site as directed and approved by the California State University Research Foundation Representative. Payment shall be made on the basis of a slurry wall constructed to the depth indicated on the drawings unless excavation to a greater depth is directed by the California State University Research Foundation Representative.

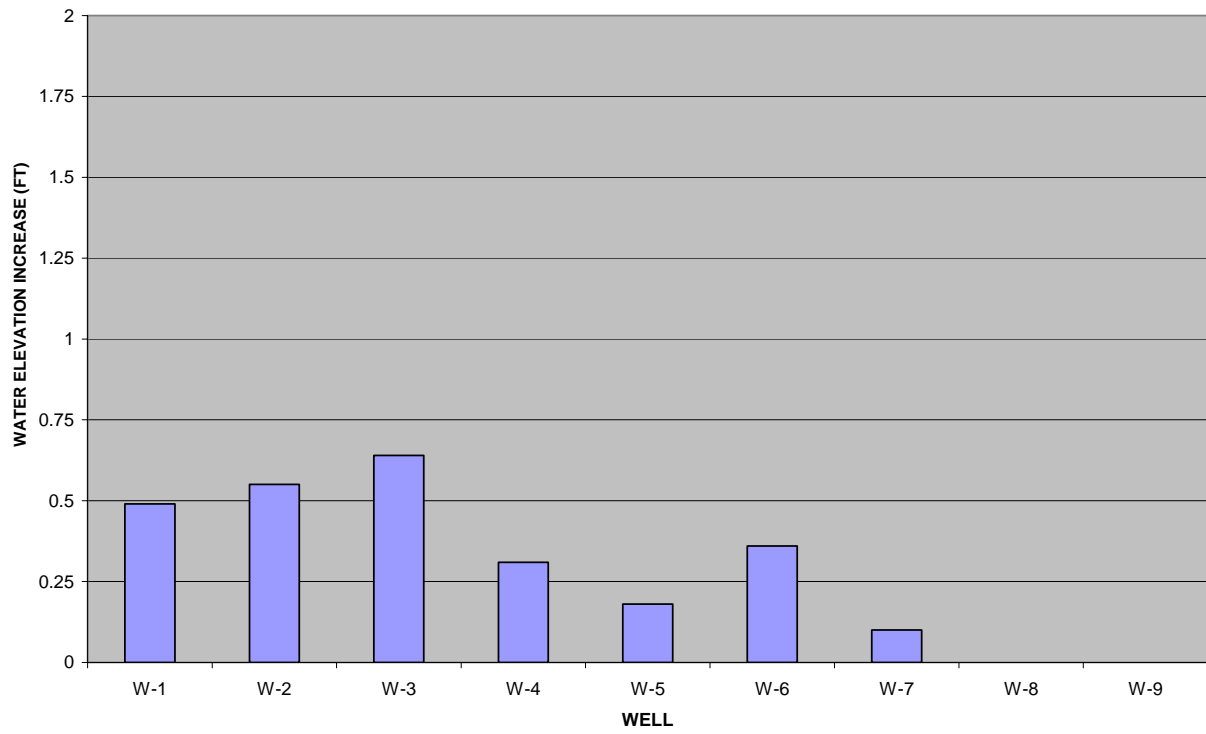
18. **PAYMENT:** Payment for slurry cutoff wall measured as specified herein before shall be made at the contract price per square foot. Such price shall include all costs of levee preparation, slurry cutoff wall installation, stockpiling or spoiling materials generated during the slurry cutoff wall installation, obtaining backfill materials from commercial sources, mixing, blending, placing the slurry cutoff wall backfill and slurry cutoff wall cap, and all other items incidental to the construction of the construction and completion of the slurry cutoff wall. No separate payment will be made for materials including bentonite, cement, additives, soil, equipment and mixing, handling and cleaning the slurry, diking around the open trench,

and overtime during continuous operations, cleanup, assistance in the collection and maintenance of records and quality control testing; such items being included in the price of the slurry cutoff wall. Final acceptance of the slurry cutoff wall will be based on meeting all the requirements for the slurry wall dimensions, bentonite slurry mix, and the approved mix design or any California State University Research Foundation Representative approved modifications to the backfill mix design.

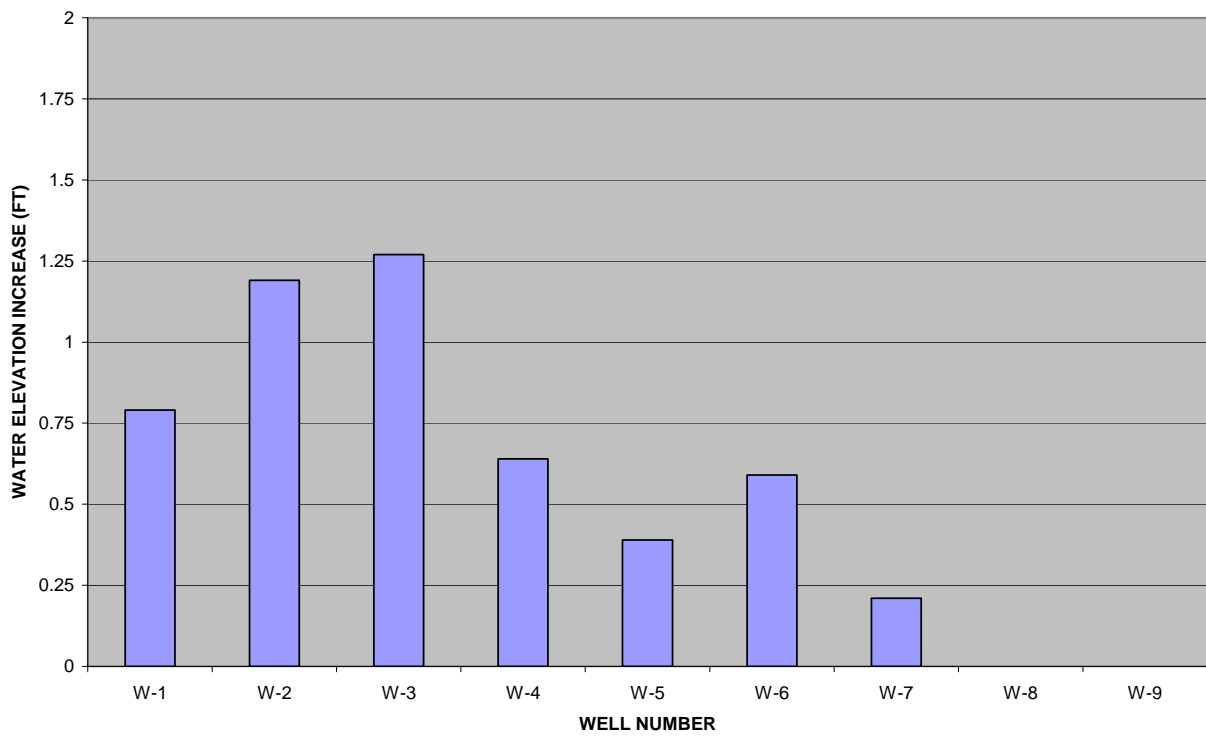
Appendix C

Monitoring Water Level Charts

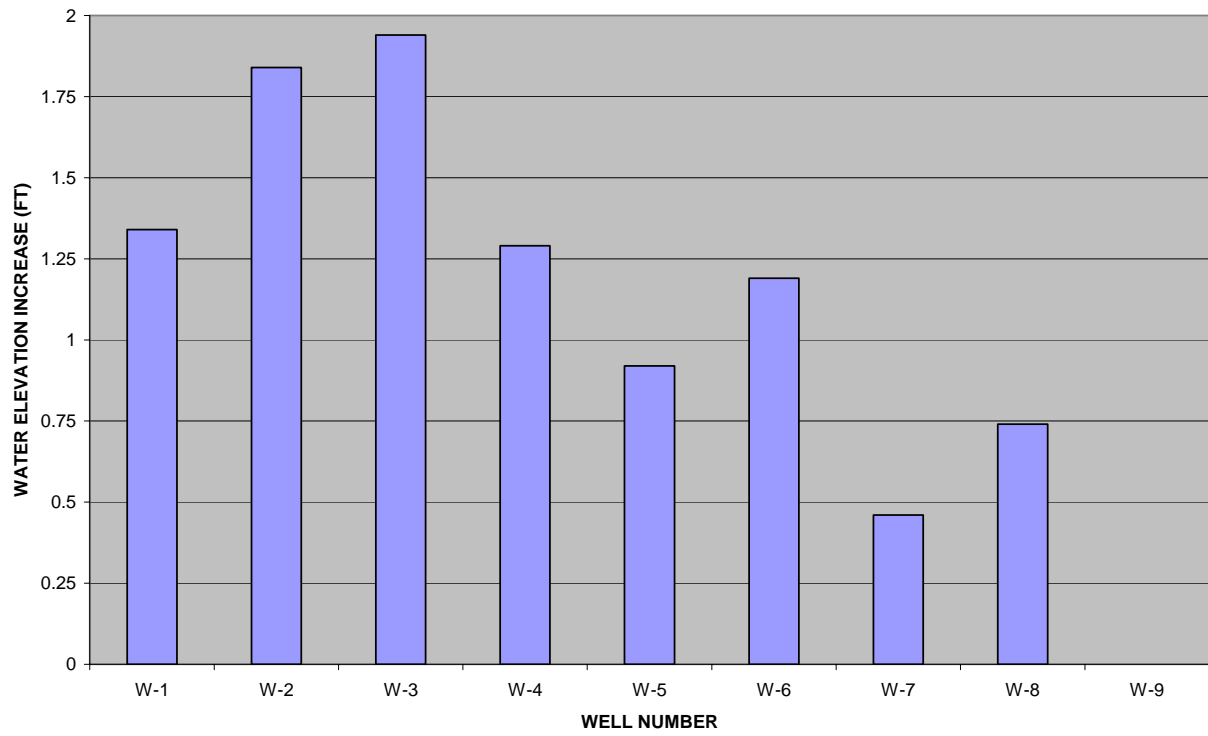
6 HOURS AFTER FILLING CANAL



12 HOURS AFTER FILLING CANAL



24 HOURS AFTER FILLING CANAL



Appendix D

Daily Construction Reports

DAILY CONSTRUCTION REPORT

Date: June 12, 1999

Weather: Sunny, Hot – Approx 90 Degrees

CONTRACTORS LABOR FORCE:

Superintendent
Motor Grader Operator
Laborer (1)

CONTRACTORS ON-SITE EQUIPMENT:

Caterpillar 14E Motor Grader (Operated approximately 7 hours)
Caterpillar IT 28 Integrated Tool Carrier (Not used)

SUMMARY OF CONTRACTOR WORK:

1. Contractor arrived on-site at 0830.
2. Morning work included:
 - cut-off monitoring wells and cap
 - install “road closed” and “road closed ahead” signage
 - begin grading of levee using Caterpillar 14E motor grader
 - grade toe of levee
3. Afternoon work included:
 - continuation of grading
 - build ramps at north and south ends for chip trucks
4. Superintendent and Laborer left the site at 1515. The grader operator continued to work until 16:30. Elevation of Levee cut down approximately 14 inches.

OTHER NOTES:

1. DWR representatives Robert L. Duffey, Inspector and Robert W. Teal, Engineering Associate arrived at the site at approximately 0845. Mr. Teal expressed concern regarding dust control and asked about a water truck. I suggested that we try to limit vehicle speed. We agreed to watch the dust problem to see if it was going to be a problem.
2. After the grader removed the road base from the levee, there was no significant dust problem. The grader was working in damp clay soil with no visible dust.
3. The DWR employees were onsite for approximately one hour in the morning and then left. They came back after lunch and were onsite for less than 30 minutes.
4. Ground water elevation data was obtained in three locations for future monitoring. The first location was in the monitoring well along the toe of the levee near the burn pile. The water level was located 4 feet below the top of the cutoff pipe. This monitoring well was capped and buried. A second monitoring well in the swamp area was tagged with pink survey tape. The location of the ground water was 22 inches below the top of the pipe that corresponds with the surface of the earth. A third location further east in the swamp area was flagged with pink tape. Standing water was found in this area. A survey stake was placed such that the top of stake was at the same elevation of the water surface.

Prepared By: Richard G. Holman

Date: June 12, 2005



View of Modified Levee Looking North



View of Modified Levee Looking South



View of Truck Ramp Looking North



Cat 14E Motor Grader, Bentonite, and IT 29

DAILY CONSTRUCTION REPORT

Date: Monday, June 14, 1999

Weather: Sunny, Hot – Approx 90 Degrees

CONTRACTORS LABOR FORCE:

Superintendent, Engineer (Approximately 1 hour each)
Laborer (2) - sporadically

CONTRACTORS ON-SITE EQUIPMENT:

Caterpillar 14E Motor Grader (Not used)
Caterpillar IT 28 Integrated Tool Carrier (used to offload 2 trucks bentonite)
Additional Equipment delivered to site (see below – not used)

SUMMARY OF CONTRACTOR WORK:

1. Contractor arrived on-site at 0715.
2. Morning work included:
 - Delivery of 2 truckloads of Bentonite
 - Peekema cut down walnut tree along toe of levee
 - Delivery of Caterpillar Generator
3. Afternoon work included:
 - Delivery of:
 - backfill mixing tank
 - Baker tank for bentonite slurry mixing
 - excavation bucket
 - fence panels for covering open excavation
 - slurry pumps, power panel, and pipe
 - Caterpillar 320L track mounted excavator
4. All Inquip employees were on site sporadically. Numerous trips were made to Marysville to coordinate the delivery of their equipment.

OTHER NOTES:

1. The gate at Evans Reimer was locked this morning. There are two locks on the gate. One lock is owned by the local landowner and the other lock is owned by DWR. I called Mr. Teal of DWR and also paged him. I received no response. The gate was cut open and repaired. I made two copies of the local landowners key. I gave one copy to Inquip and kept one for myself.
2. I spoke with Karen Barstow of Golden By-Products. I requested one truckload of tires (24 tons) on Thursday between 1000 and 1200. I also requested three truckloads on Friday at 1000, 1400, and 1600. I told her that I would call her Thursday afternoon to confirm the Friday deliveries. She expressed that she would prefer to not work on Sunday however if the contractor needed deliveries, she would meet their requirements.
3. I met with Doak Cotter from the Water District. He confirmed that using levee water was acceptable.
4. At 1700, I received a call from Inquip (JP). They have changed to an 18" wide bucket. This will lessen their required quantity of tires from 530 tons down to 385 tons. He said that each 24 ton truckload would be approximately 7.3, 18 cubic yard batches. He thought that each batch would take approximately 20 minutes to mix and place.
5. Ordered a construction office trailer and a project sign.

Prepared By: Richard G. Holman

Date: 14-Jun-99



Baker mixing tank for bentonite slurry



Walnut tree removal by Peekema



Cat 320L Excavator for backfill



IT 28 offloading bentonite

DAILY CONSTRUCTION REPORT

Date: Tuesday, June 15, 1999

Weather: Sunny, Hot – Approx 90 Degrees

CONTRACTORS LABOR FORCE:

Superintendent, Engineer (Approximately 1 hour each)
Craft Labor (6)

CONTRACTORS ON-SITE EQUIPMENT:

Caterpillar 14E Motor Grader (Not used)
Caterpillar IT 28 Integrated Tool Carrier (used to offload 2 trucks bentonite)
2 Baker Slurry mixing tanks
Slurry mixing pump and panel
Caterpillar Generator
Caterpillar 320L track mounted excavator
HDPE pipe fusing equipment

SUMMARY OF CONTRACTOR WORK:

1. Contractor arrived on-site at 0715.
2. Morning work included:
 - Delivery of 1 truckload of Cement
 - Arrange slurry mixing equipment/generator
 - Built Forms for backfill visual inspection test
3. Afternoon work included:
 - Assembly (fusing) of HDPE slurry pipe (approx. 40 feet every 5.5 minutes)
 - Assembly of water supply pipe
 - Crews worked until 1830
 - Piping of slurry mixing tank/pumps for re-circulation
 - Delivery of Lignosulfate retarder for backfill

OTHER NOTES:

1. I called Mr. Teal with DWR to confirm excavation scheduled for Thursday. I also informed him that minor excavation was occurring to place the water supply line. He said that he should be on site around noon on Thursday, June 17, 1999.
2. One of the road closed signs was missing this morning. I asked the lead laborer to ensure that the road closure was clearly marked at the end of the day.
3. I partially assembled the backfill inspection test forms.
4. I expressed to Dennis Thompson (superintendent) that I was concerned about the truck ramps. He said he would work on them on Wednesday.
5. JP (Inquip Engineer) asked about the base plate for the slump test. Apparently they can't locate one. I told him we would bring a clean metal tray from our concrete laboratory.
6. All personnel were wearing vests and hardhats. This is something that we need to watch.



Backfill Visual Inspection Test Forms



HDPE pipe fusing equipment



Slurry Mixing Tanks, Pump, and Control Panel



Integrated Tool Carrier dragging HDPE slurry pipe

DAILY CONSTRUCTION REPORT

Date: Wednesday, June 16, 1999

Weather: Sunny, Hot – Approx 90 Degrees

CONTRACTORS LABOR FORCE:

Superintendent, Engineer (Approximately 3 hours each)
Craft Labor (6)

CONTRACTORS ON-SITE EQUIPMENT:

Caterpillar 14E Motor Grader (Not used)
Caterpillar IT 28 Integrated Tool Carrier (used to offload 2 trucks bentonite)
2 Baker Slurry mixing tanks
Slurry mixing pump and panel
Caterpillar Generator
Caterpillar 320L track mounted excavator
HDPE pipe fusing equipment
Additional Deliveries (see below)

SUMMARY OF CONTRACTOR WORK:

1. Morning work included:
 - Delivery of 1 truckload of Cement
 - Mix one batch of bentonite slurry in Baker tanks
 - Delivery of Caterpillar 235C track mounted excavator
 - Delivery of Caterpillar 953 track mounted front end loader
 - Diesel pump delivered and connected – operational
2. Afternoon work included:
 - Completion of fusing HDPE slurry pipe – complete by 1700
 - Mixing second batch of bentonite slurry

OTHER NOTES:

1. Bentonite not mixing very well with water. Soda ash added to soften the water.
2. Re-confirmed specification requirement that mix design may need to be modified after first batch. Spoke with both Dennis and JP. JP concerned about W-C ratio.
3. Cat 235C excavator was delivered and had experienced some damage to the cab. Equipment was rented from Jaeger. Jaeger visited the site and confirmed damage. Equipment is operational.
4. Ground water elevation was down 4" today. I requested watering records for the landowner across the canal. Left message.
5. Levee is now approximately 21 feet wide. The plan for the backfill operation is to put the Cat 320L on one side of the excavation and the mixing box on the other side of the excavation. Track width of 320L = 10'-5", Trench = 1.5', Mixing Box = 7'-9". Total width = 19'-8". Only 1'-4" extra room.
6. Plan is to spend the morning of June 17, 1999 changing the stick and bucket on the Cat 235D and beginning excavation around noon. First delivery of tire chips is scheduled for 1000. Karen Barstow has expressed a desire to not work on Sunday, June 20 (Fathers Day). Dennis Thompson of Inquip expressed that this decision will be made based on progress achieved.

Prepared By: Richard G. Holman

Date: 16-Jun-99



Loading Bentonite Mixing Tank



Diesel Water Supply Pump



Cat 953 Track Mounted Front End Loader



Backfill Mixing Tank

DAILY CONSTRUCTION REPORT

Date: Thursday, June 17, 1999

Weather: Sunny, Hot – Approx 90 Degrees

NOTES:

1. Contractor working on Equipment until approximately 1630.
2. Excavation started at 1630.
3. Mixed two batches of backfill. Slump approximately 5.5 inches after adding additional soil. Second batch started with less slurry due to moisture content in soil from bentonite.
4. Made two compressive strength cylinders and one permeability cylinder.
5. Roger Formanek of CIWMB on-site
6. Picked up project sign.
7. Contractor worked 0700-2030



Dragging Mixing Bucket to Excavation Area



First Delivery of Tire Chips



Dumping First Load of Tire Chips



First Bucket of Excavation



Bentonite Slurry



Excavation of Trench



Addition of Rubber Tires to Backfill

DAILY CONSTRUCTION REPORT

Date: Friday, June 18, 1999

Weather: Sunny, Hot – Approx 95 Degrees

CONTRACTORS LABOR FORCE:

Superintendent, Engineer
Craft Labor (8)

CONTRACTORS ON-SITE EQUIPMENT:

Caterpillar 14E Motor Grader (Not used)
Caterpillar IT 28 Integrated Tool Carrier
2 Baker Slurry mixing tanks
Slurry mixing pump and panel
Caterpillar Generator
Caterpillar 320L track mounted excavator
HDPE pipe fusing equipment
Caterpillar 235C track mounted excavator
Caterpillar 953 track mounted front end loader
Diesel pump – Not being used

SUMMARY OF CONTRACTOR WORK:

1. Morning work included:
 - Cat 235 Excavating Trench
 - Mixed six batches of backfill
 - Continued mixing bentonite
 - Slump averaging 4-6"
 - Trailer Delivered to site
2. Afternoon work included:
 - Mixed two batches of backfill – stopped backfill; catching up to excavator
 - Made one cylinder for compressive strength and one for permeability

OTHER NOTES:

1. Received three truckloads of chips. Had problems with the first driver complaining about the access road to his dispatcher. Lynn of Sukut Construction came over from Oroville and found a better access road. Next two drivers had no problems.
2. Jim Barstow of Golden Byproducts visited the site in the afternoon.
3. Fencing was not placed over the excavation last night. It was placed at the end of today's shift.
4. Water elevation of monitoring well has dropped one inch since Wednesday.
5. At the end of the shift, the backfill station is at 01+20 and the excavation station is at 02+70. (150 feet between backfill and excavator).
6. Worked 14 hours today. I would estimate that the contractor excavated three hours yesterday and eleven hours today. The total distance of excavation excluding the lead-in is 270 feet. This is an average of 20 feet per hour. At this rate, the excavation would be complete in 57 working hours.

Prepared By: Richard G. Holman

Date: 18-Jun-99



Excavation and Backfill Operation



Excavator at 27' of depth



Mixing backfill – Cement Hopper, Tires, and Soil



5.5 Inches of Slump

DAILY CONSTRUCTION REPORT

Date: Saturday, June 19, 1999

Weather: Sunny, Hot – Approx 90 Degrees

CONTRACTORS LABOR FORCE:

Superintendent, Engineer
Craft Labor (8)

CONTRACTORS ON-SITE EQUIPMENT:

Caterpillar 14E Motor Grader (Not used)
Caterpillar IT 28 Integrated Tool Carrier (2)
2 Baker Slurry mixing tanks
Slurry mixing pump and panel
Water supply pump
Caterpillar Generator
Caterpillar 320L track mounted excavator
HDPE pipe fusing equipment
Caterpillar 235C track mounted excavator
Caterpillar 953 track mounted front end loader

SUMMARY OF CONTRACTOR WORK:

1. Morning work included:
 - Did not start excavating until 0840. Had problems with bushing near bucket on excavator. Dennis Thompson drove into Sacramento to pick up a replacement and a spare.
 - Project Sign erected.
 - Excavation and backfill continued
2. Afternoon work included:
 - Continued excavation and backfill
 - Took samples – 4" slump
 - Inquip still having problems with slurry plant. May stop backfill early to work on the plant.

OTHER NOTES:

1. Received two truckloads of chips.
2. Paul Russell of Sutter-Butte Water District visited the site. He was very pleased with the progress of the project.
3. Fencing was placed over the excavation last night.
4. I reminded Dennis Thompson that once the backfill passes the clearing in the orchard, he would need to consider a different truck delivery routing. He said that he may just have the trucks back up to the levee and dump their load. He would then tram the chips to the mixing bucket.
5. Water elevation of monitoring well is 5" below grade. (no change)
6. Received new (rebuilt) teeth for the excavator. New teeth are expected by Monday.
7. Excavation continues to be moving at about 20 feet per hour.
8. Worked 12 hours. Contractor not working on Sunday.

Prepared By: Richard G. Holman

Date: 19-Jun-99



Bushing Repair on 235 Excavator



Excavator Repair



Project Sign



Project Sign

DAILY CONSTRUCTION REPORT

Date: Monday, June 21, 1999

Weather: Sunny, Hot – Approx 90 Degrees

CONTRACTORS LABOR FORCE:

Superintendent, Engineer
Craft Labor (8)

CONTRACTORS ON-SITE EQUIPMENT:

Caterpillar 14E Motor Grader (Not used)
Caterpillar IT 28 Integrated Tool Carrier (2)
2 Baker Slurry mixing tanks
Slurry mixing pump and panel
Water supply pump
Caterpillar Generator
Caterpillar 320L track mounted excavator
HDPE pipe fusing equipment
Caterpillar 235C track mounted excavator
Caterpillar 953 track mounted front end loader

SUMMARY OF CONTRACTOR WORK:

1. Morning work included:
 - Excavation and backfill continued
2. Afternoon work included:
 - Continued excavation and backfill
 - Took samples – 5.5" slump

OTHER NOTES:

1. Received two truckloads of chips.
2. Lynn and Gail from the Oroville site visited the project. They suggested that we take four loads of tires on Tuesday and four loads on Wednesday to allow them to clean up their site. I spoke with Dennis Thompson and he agreed. I called Karen at Golden By-Products. We will have trucks at 0700, 1000, 1300, and 1600 on both Tuesday and Wednesday.
3. Water elevation of monitoring well is 5" below grade. (no change) The landowner across the canal has begun watering. We will need to keep an eye on the monitoring well.
4. The project experienced a significant increase in progress today. 260 lineal feet of backfill was placed. The excavator is approximately 150 feet ahead of the backfill crew
5. Worked 12 hours.
6. Had press conference at 1100.
7. Aerial photographs taken at 1100.
8. No progress photographs taken today.
9. Three test cylinders taken today. Vector to deliver a fresh set of cylinders tomorrow afternoon.

Prepared By: Richard G. Holman

Date: 19-Jun-99

DAILY CONSTRUCTION REPORT

Date: Wednesday, June 23, 1999

Weather: Sunny, Hot – Approx 95 Degrees

CONTRACTORS LABOR FORCE:

Superintendent, Engineer

Craft Labor (6)

CONTRACTORS ON-SITE EQUIPMENT:

Caterpillar 14E Motor Grader (Not used)

Caterpillar IT 28 Integrated Tool Carrier (2)

2 Baker Slurry mixing tanks

Slurry mixing pump and panel

Water supply pump

Caterpillar Generator

Caterpillar 320L track mounted excavator

HDPE pipe fusing equipment

Caterpillar 235C track mounted excavator

Caterpillar 953 track mounted front end loader

SUMMARY OF CONTRACTOR WORK:

1. Morning work included:
 - Excavation and backfill continued
2. Afternoon work included:
 - Continued excavation and backfill

OTHER NOTES:

1. High ranking visitors from DWR on site.
2. Four loads of tires delivered.
3. Water elevation of monitoring well is 8" below grade. Landowner across the canal has continued to water his crops.
4. The excavator is at station 11+10 – only 290 more feet to excavate – excavated 200 feet today.
5. Backfill is 74% complete. 17% percent of the backfill was placed today.
6. Spoke with Dave Ricketts of USCOE today. He may visit the site on Friday morning. He will call me tomorrow afternoon to confirm that the contractor has not finished.
7. Contractor worked 12 hours.
8. Three test cylinders taken today. – two for compression and one for permeability.
9. Contacted Von Geldern Engineering regarding compaction testing of the levee road. We will use DWR specifications which are slightly different from USCOE specifications. A representative of Von Geldern will contact me at the site in the morning to prepare the maximum dry density curve.
10. The cutoff wall should be complete by Friday. Saturday work will include general site grading and site cleanup including dismantling of the bentonite plant. The contractor will not work Sunday. Levee roadway reconstruction is scheduled to start on Monday, June 28, 1999.
11. Today's progress photos include an overview of the mixing process.

Prepared By: Richard G. Holman

Date: 23-Jun-99



Step 3: Rubber tires added after cement-bentonite thoroughly mixed



Step 4: Soil Added to obtain slump



Step 1: Excavator Adds Bentonite from Trench into Mixing Bowl



Step 2: Cement hopper adds cement via trap door in bottom

DAILY CONSTRUCTION REPORT

Date: Wednesday, June 24, 1999

Weather: Sunny, Hot – Approx 85 Degrees

CONTRACTORS LABOR FORCE:

Superintendent, Engineer
Craft Labor (6)

CONTRACTORS ON-SITE EQUIPMENT:

Caterpillar 14E Motor Grader (Not used)
Caterpillar IT 28 Integrated Tool Carrier (2)
2 Baker Slurry mixing tanks
Slurry mixing pump and panel
Water supply pump
Caterpillar Generator
Caterpillar 320L track mounted excavator
HDPE pipe fusing equipment
Caterpillar 235C track mounted excavator
Caterpillar 953 track mounted front end loader

SUMMARY OF CONTRACTOR WORK:

1. Morning work included:
 - Excavation and backfill continued
2. Afternoon work included:
 - Continued excavation and backfill
 - Cleanup of rubber and waste soil along toe of levee

OTHER NOTES:

1. Two visitors from USCOE – Mike Ransbotham and Ed Flynt.
2. Five loads of tires delivered – Tire deliveries complete
3. Water elevation of monitoring well is 8" below grade. Water elevation near farmhouse dropped two inches between 1400-1700 (3 Hours).
4. The excavator is at station 13+45 – only 51 more feet to excavate. Backfill daylight is at 12+70.
5. Backfill is 93% complete. 19% percent of the backfill was placed today.
6. Contractor worked 12 hours.
7. Three test cylinders taken today. – two for compression and one for permeability.
8. Working on compaction requirements for levee road. Bob Teal contacted me and stated that rubber tire chips were not acceptable in the floodway. Preparing a proposed plan to accommodate his requirement.
9. The cutoff wall should be complete by Friday. Saturday work will include general site grading and site cleanup including dismantling of the bentonite plant. The contractor will not work Sunday. Levee roadway reconstruction is scheduled to start on Monday, June 28, 1999.
- 10.

Prepared By: Richard G. Holman

Date: 24-Jun-99



Monitoring Stick – 2" water surface drop in 3 hours today

DAILY CONSTRUCTION REPORT

Date: Monday, July 12, 1999

Weather: Sunny, Hot – Approx 110 Degrees

CONTRACTORS LABOR FORCE:

Anderson Dragline – First Day
Darrel – Foreman/Motor Grader Operator
Scraper Operator
Water Truck Operator

CONTRACTORS ON-SITE EQUIPMENT:

Caterpillar 163H Motor Grader (0700)
Caterpillar 615 Self Loading Scraper (0700)
Front End Loader (1400)
Soil Screen (1500)

SUMMARY OF CONTRACTOR WORK:

1. Contractor arrived on-site at 0630.
2. Morning work included:
 - Using Blade and Motor Grader return levee to original line and grade
3. Afternoon work included:
 - Scraper continued to work on moving earth into a stockpile for screening
 - Darrel coordinated equipment deliveries

OTHER NOTES:

1. New DWR Inspector Mr. Steve Dawson onsite approximately 0645.
2. Mr. Dale L. Whitmore, Department of Fish and Game onsite at approximately 0700. I expressed that we would like to put all excess soil in the swamp area. He referred to this area as a wetland. I noted that this was not actually a wetland but an orchard that has been inundated due to seepage from the levee. Mr. Dawson noted that if any material is to be placed in the swamp, that DWR permission would be required, and that the material would need to be screened. I stated that we would either request an exemption to place the screened material in the swamp, or we would haul the material off-site but that this work did not need to be completed until November.
3. Contractor working on removal of soil/rubber from top, slope, and toe of levee.
4. Work may require final removal of rubber by hand or raking.
5. At approximately 1430, I received a call from the inspector informing me that a problem had developed at the north end of the slurry wall. He described it as a deep hole approximately 4-7 cubic yards in volume. I returned to the site to investigate. The hole was 6 feet deep approximately 2' x 2' in area (plan view). It appears that there is a connection between the hole and the canal. The hole was covered and safety signage was installed. Professor Bruce Yoakum P.E. arrived on site at approximately 1630 to investigate. Inspector Steve Dawson notified DWR management of the condition. A meeting will be held sometime around noon tomorrow to discuss potential resolution of this condition.
6. I called Inquip to inform them of the condition. Mr. Gene Hensgen, President, stated that if in fact the cause of the void was related to their work, that he would authorize Anderson Dragline to perform any necessary repairs and backcharge Inquip. I told him that I did not know the cause of the void. I told him that I would get back to him as the situation develops.

Prepared By: Richard G. Holman

Date: 12-Jul-99



View of potential cause of void
Note concrete patch in upper left-hand corner of photo



View looking down the void from the top of the levee

DAILY CONSTRUCTION REPORT

Date: Tuesday, July 13, 1999

Weather: Sunny, Hot – Approx 105 Degrees

CONTRACTORS LABOR FORCE:

Darrel – Foreman/Motor Grader Operator
Scraper Operator
Water Truck Operator (partial day)

CONTRACTORS ON-SITE EQUIPMENT:

Caterpillar 163H Motor Grader
Caterpillar 615 Self Loading Scraper
2 each Front End Loaders (second arrived approx. 1300)
Soil Screen
Motor Grader and Scraper were taken off rent according to Darrel

SUMMARY OF CONTRACTOR WORK:

1. Contractor working 0700 – 1630.
2. Morning work included:
 - Approx. 2 hours with Blade & Motor Grader along toe and on top of levee
3. Afternoon work included:
 - Changed Screen to ¾ inch – material acceptable to DWR (Karen and Steve)
 - Screening stockpile of soil – using two loaders. Material that is rejected from screen is worked to break down soil and then re-screened.

OTHER NOTES:

1. At approximately 0815, a second void developed in the levee at station 13+75. A scraper was near the new void when it opened up. It appeared approximately seven feet deep and had a few inches of water in the bottom.
2. Spoke to Gene Hensgen of Inquip. I requested that if we were to do any excavation or exploratory testing, that he have a representative on-site. He agreed. Dennis Thompson will be back in town on July 20, 1999. Gene will be in Marysville from July 14-21.
3. Doak Cotter and the entire Board of Directors visited the site. They expressed the importance of continual flow of water in this peak watering season. He noted that starting September 1, 1999, flows might be reduced.
4. Bruce Yoakum on-site at 1200.
5. Roger Formanek and Martha Gildart on-site at approximately 1200.
6. Screening process started with 1" screens – material rejected by inspector. Guy Rents delivered ¾" screens – material accepted by Steve Dawson and Karen (maintenance).
7. Ricardo Pena and Victor from Sacramento DWR office onsite at 1300. They observed the situation and requested a proposal from CSU/CIWMB to resolve the problem. During this visit Professor Yoakum inserted a long piece of PVC pipe into the north void, it reached a depth of approximately 14 feet below grade.
8. One option discussed was to use a cone penetrometer to perform subsurface explorations with emphasis on searching for voids. I contacted Andy Taber of Taber Consultants. He noted that a cone penetrometer could perform 400-500 lf of exploration per day. He also noted that this would cost approximately \$5.50 to \$7.50 per foot depending on the data required.
9. Plywood covers were placed over the holes in the levee and caution tape was utilized.

Prepared By: Richard G. Holman

Date: 13-Jul-99



Location of holes – second hole located 19 feet south of the first



Screening Operation

AUGUST 10, 1999



RUBBER RAKING CREW



TIRE CHIPS RECOVERED FROM TOP OF LEVEE

AUGUST 11, 1999



EXCAVATOR MOVING SCREENED FILL



LOADER MOVING SCREENED FILL



BELLY DUMP TRUCKS DELIVERING ADDITIONAL FILL



LASER LEVEL USED FOR GRADING

AUGUST 13, 1999

LEVEE ROAD OPEN TO TRAFFIC



Appendix E

Laboratory Test Results

LABORATORY TRANSMITTAL

DATE: October 22, 1999

JOB NO: 973016.01

LAB LOG: 137.0

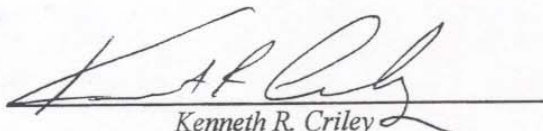
TO: Richard G. Holman
California State University, Chico
Department of Construction Management
Chico CA 95929-6355

cc: Bruce Yoakum
Same

RE: Laboratory Testing: Recycled Tire Slurry Wall

Enclosed are result for:

Code	Item	Quantity
	Hydraulic Conductivity, D-5084-12"	6
	Compressive Strength, D-2166- 12"	11
	Hydraulic Conductivity, D-5084- 2"	1
	Compressive Strength, D-2166- 2"	4
	Construction of 12" molds, 7-12x12 & 14 12x24	21


Kenneth R. Criley
Technical Director

October 22, 1999
Project No: 973016.01

Richard G. Holman
California State University, Chico
Department of Construction Management
Chico, CA 95929-6355

Re: Laboratory Services, Recycled Tire Slurry Wall Project

Dear Richard:

Our laboratory has completed testing for the referenced project. The testing program included tests to measure the hydraulic conductivity and strength characteristics of test samples obtained from field mixes, during construction of the slurry wall.

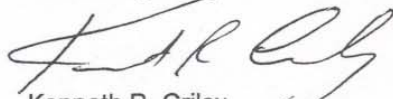
Enclosed are 7 Hydraulic Conductivity and 15 Unconfined Compressive Strength tests. The tests were conducted on 12-inch diameter specimens. The specimens were fabricated at the project site near Gridley California, and later transported to our Grass Valley lab for these tests.

The test program required fabrication of test samples from on site mixes for each day of production, and casting multiple specimens for strength and hydraulic conductivity tests at 7 and 28 days of curing age. Representatives from Chico State performed the sampling and specimen fabrication. After curing for at least 3 days these specimens were delivered to Vector's laboratory for testing.

Our laboratory encountered some difficulties in conducting the hydraulic conductivity tests at the scheduled 7 and 28 day, however the strength tests were performed as requested. The Hydraulic Conductivity tests required several weeks of individual specimen cell time. With only three cells and other problems, actual 7 and 28-day test results were not determined, and test results were obtained at various curing times from 7 to 50 days of age. The long test times were due to the size of the test samples and some equipment problems. Difficulties were encountered with wires from the tires puncturing the test membranes, which required several cell and sample repairs.

I apologize for the delay in this report. Please call me if you have any comments or question.

Sincerely Yours
Vector Engineer Inc.



Kenneth R. Criley
Director of Laboratory Services

Labexcell / Lab-word / letters / chico-tires-final

12438 Loma Rica Dr., Suite C • Grass Valley, CA 95945 • (530) 272-2448 Fax: (530) 272-8533
MENDOZA & BUENOS AIRES, ARGENTINA • SANTIAGO, CHILE

Strength and Hydraulic Conductivity

Laboratory Services

CLIENT NAME
CALIFORNIA STATE UNIV., CHICO

PROJECT NO:

973016.01

Summary Report

REPORT DATE:
October 15, 1999

REPORT NO.:

1

PROJECT NAME
RECYCLED TIRE SLURRY WALL PROJECT

Date Cast	Client ID	Lab Identification	Hydraulic Conductivity, cm / sec		Dry Density Pcf	Unconfined Compressive Strength, psi	
			Age	k, cm / sec		Water Content %	
6/17/99	12"	137A	14 - Day	6.5E-07	40.7	74.6	7 - Day 14.0 28 - Day 20.8
6/17/99	2"	137B	7 - Day	7.3E-07	45.5	74.8	18.5 19.7 29.0 27.4
6/18/99	12"	137C	21 - Day	2.6E-07	40.9	69.1	18.3 NA
6/19/99	12"	137D	21 - Day	6.7E-07	46.5	69.7	13.3 21.3
6/21/99	12"	137E	40 - Day	8.3E-07	40.0	68.2	19.9 28.2
6/23/99	12"	137F	28 - Day	1.5E-07	42.2	75.0	17.8 27.4
6/24/99	12"	137G	50 - Day	3.7E-07	52.0	61.2	19.9 22.0

REVIEWED BY: